PV-HYBRID SYSTEMS IN REMOTE AREAS – COST SAVING POTENTIAL FOR ISLANDS AND MINES

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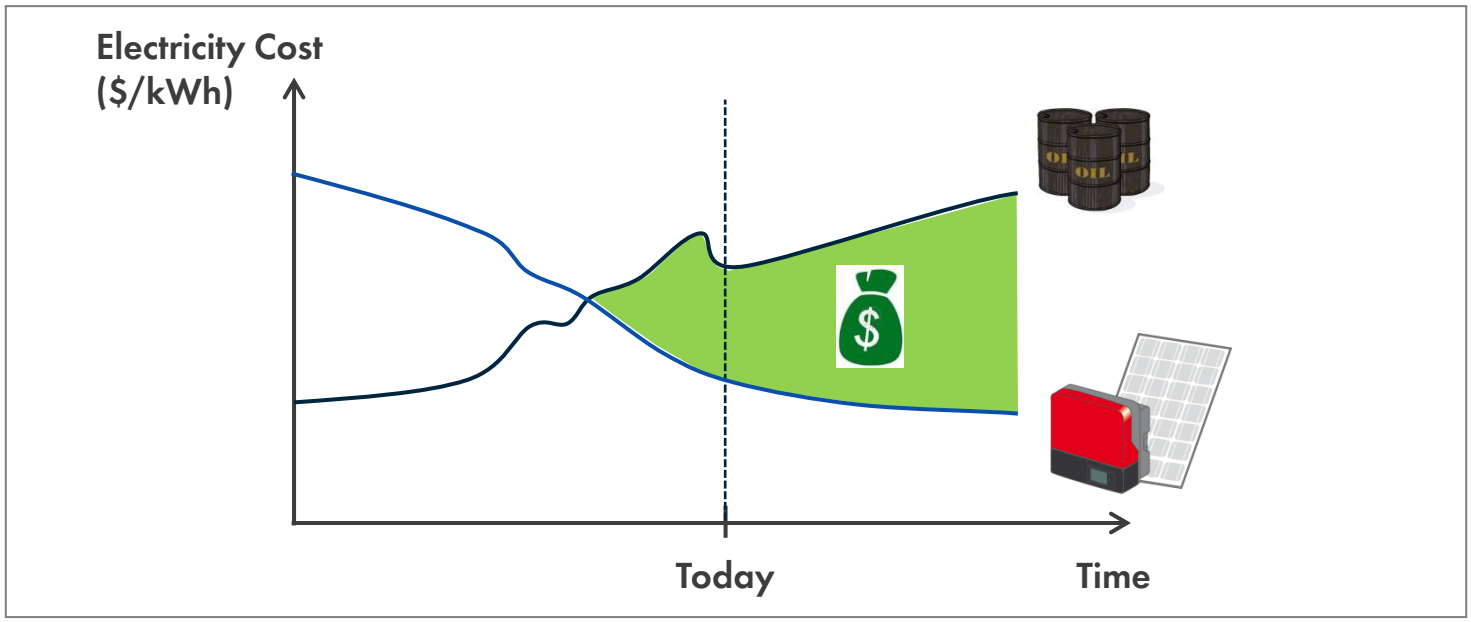
MOTIVATION:
WHY DO WE TALK ABOUT PV-DIESEL HYBRID SYSTEMS?



The cost advantage of PV-Diesel hybrid systems compared to conventional Diesel Gensets will become even more dominant in the future!

Fluctuation of oil/Diesel price will always remain!

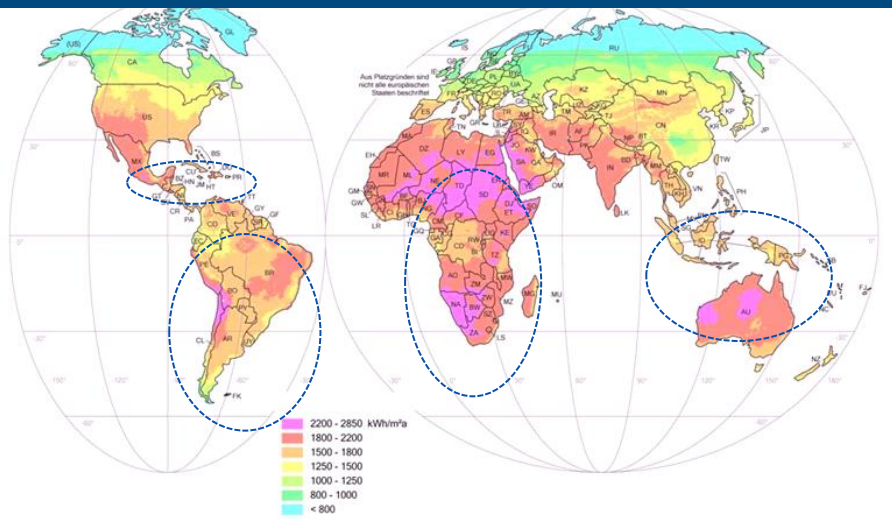
Source: SMA

AGENDA

1. **PV-Hybrid market opportunities**
2. Financial attractiveness
3. Technical solutions and references
4. Summary and conclusion

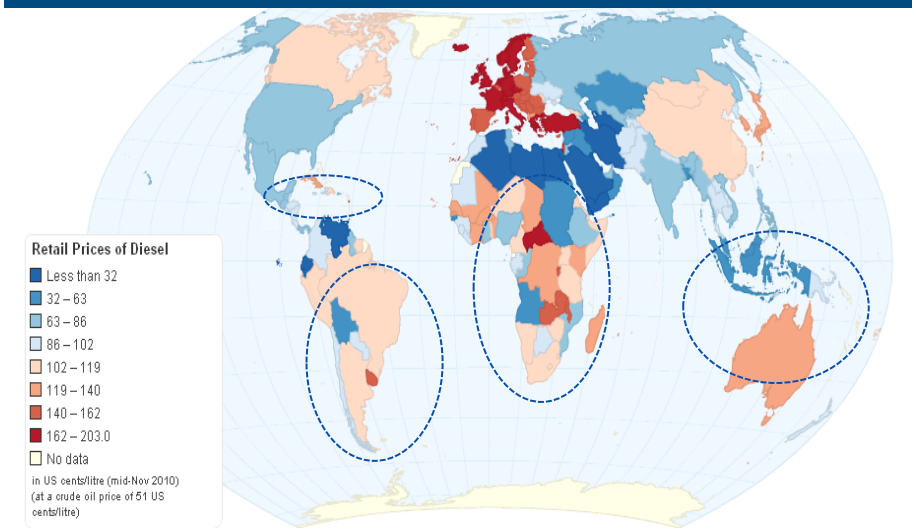
OUR ANALYSIS OF THE GEOGRAPHICAL MARKET SELECTION SHORT LISTS SEVERAL COUNTRIES WITH HIGH MARKET POTENTIAL

Annual global solar irradiation



Source: http://chartsbin.com/view/1128

Worldwide diesel prices



Source: http://chartsbin.com/view/1128

Focus markets

- Caribbean
- Indonesia/Malaysia
- Sub-saharan Africa
- Central America
- South America
- Australia

Source: SMA

THERE ARE MANY DIFFERENT APPLICATIONS FOR PV-DIESEL HYBRID SYSTEMS

Focus of this presentation

Remote electrification (islands)
(e.g. Caribbean or Oceania)

Heavy industries
(e.g. mining, oil&gas)

Tourism
(e.g. hotels, resorts)

Big Agriculture
(e.g. irrigation systems, farms)

Utilities/ IPP
(in off-grid/weak-grid regions)

Remote hospitals
(in off-grid/weak-grid regions)

Real estate
(e.g. offices, warehouses)

Remote industries
(in off-grid/weak-grid regions)

Military
(e.g. off-camps, training facilities, military base power plants)

Telecom industries and remote pumps
(in off-grid/weak-grid regions)

Rural electrification
(in off-grid/weak-grid regions)

Rental power

Source: SMA

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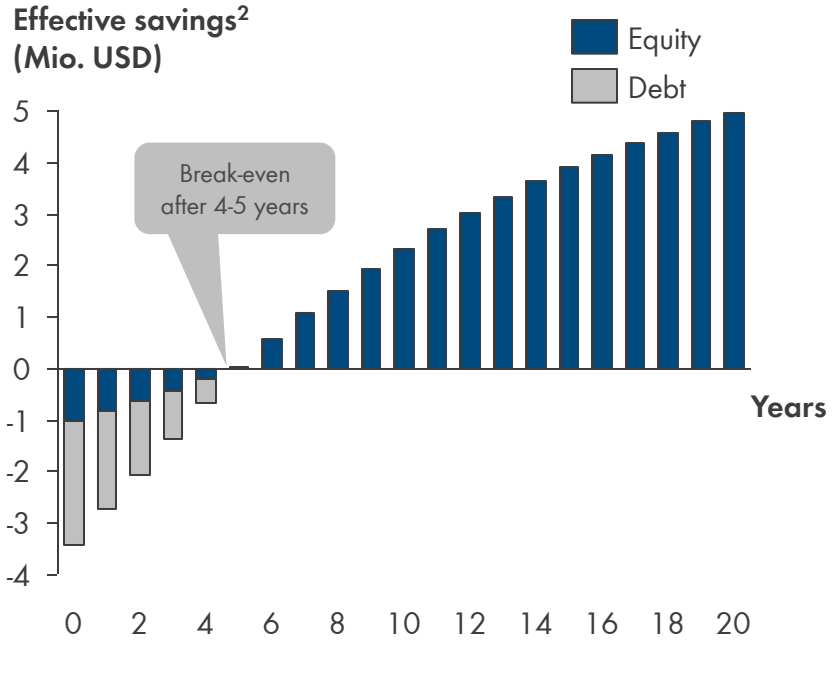
A DETAILED CASHFLOW ANALYSIS CLEARLY SHOWS THE FINANCIAL ATTRACTIVENESS OF PV-DIESEL HYBRID

Assumptions (Base Case)

- System is designed such that all generated PV energy can be used
- No annual increase of fuel cost included!
- PV plant size: 2 MWp
- Specific yield (PV): 1600 kWh/kWp p.a.
- PV system cost[1]: 1700 USD/kWp CapEx (+ OpEx 2% p.a.)
- Effective fuel cost: 1.00 USD/litre
- Genset efficiency: 3.5 kWh/litre
- PV financing: 30% equity, 70% debt (with 7% interest rate and 5 year amortisation time); cashflow discount factor: 8%

DCF[2] Analysis

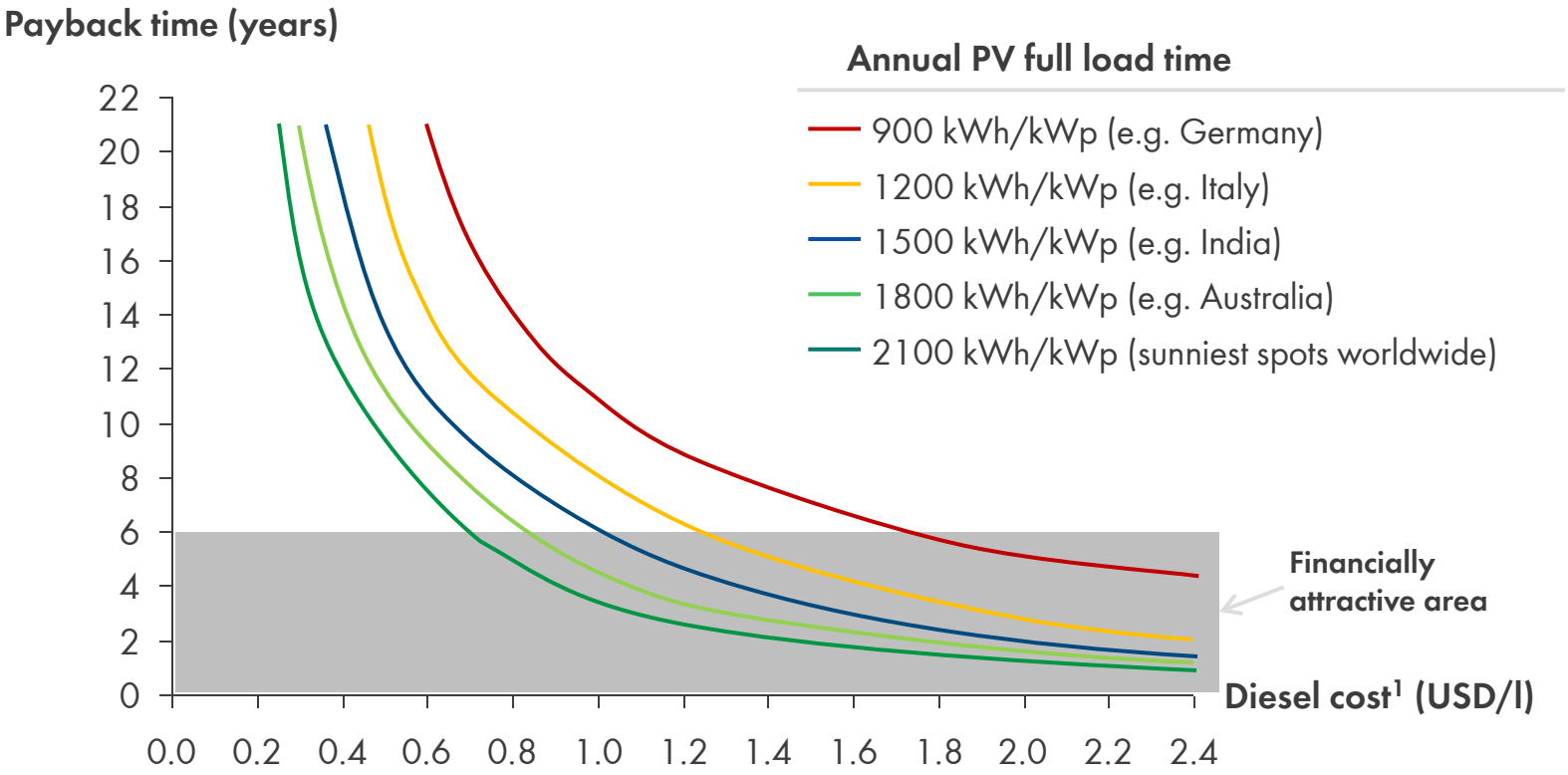


Payback time of the investment into PV-Diesel-Hybrid is just 4-5 years!

Moreover, avoidance of power outages brings down opportunity cost significantly!

1. PV system cost will significantly depend on country and project specifications 2. Discounted Cash Flows
Source: SMA analysis

PV-DIESEL-HYBRID IS ALREADY A REAL BUSINESS CASE IN SUNNY REGIONS WITH DIESEL COST > 1 USD/LITER



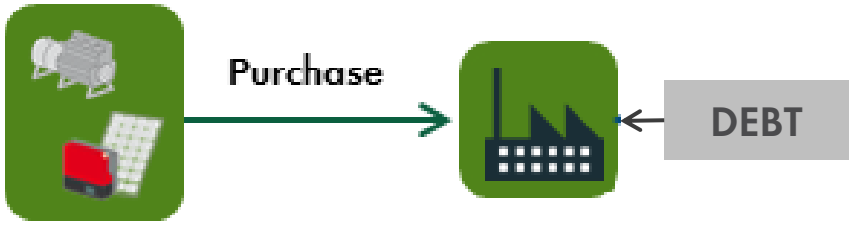
1. Effective cost at point of consumption including fuel transportation and storage cost etc.
Assumptions : 1 MW PV plant; 100% consumption of PV power possible; CapEx=2,000 USD/kWp; OpEx= 2% of CapEx p.a.; PV financing with 30% equity/70% debt with 7% interest rate and amortization time of 5 years; Genset efficiency 3.5 kWh/l (net electricity production); CapEx and Maintenance cost for Diesel genset not included, since PV is considered as add-on here, not as genset hardware substitution
Source: SMA analysis

FINANCING IS STILL AN ISSUE FOR PV-HYBRID, EVEN THOUGH SEVERAL FINANCING MODELS EXIST IN THE MARKET PLACE

A) Customer buys + organizes finance

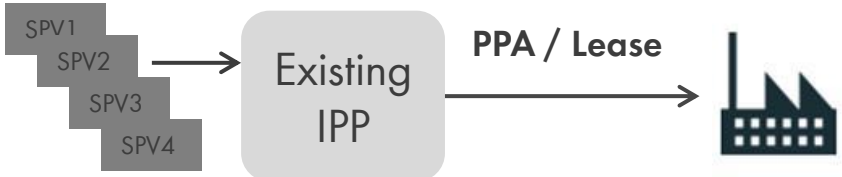
- Ideal situation for all stakeholders involved (very rare)
- Easy business

B) Customers buys + needs finance



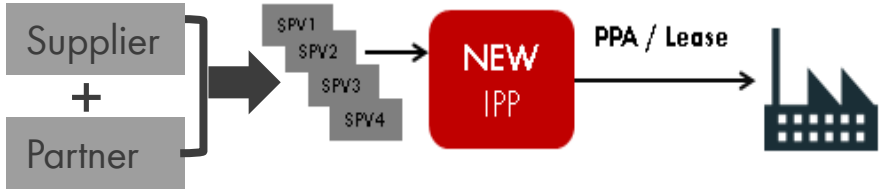
- End customer/owner provides equity
- Local or international banks bring in debt

C) Customer wants PPA/Leasing – existing IPP



- Projects are bundled into SPV[1]
- SPVs are bought by an existing IPP[2]
- IPP sells power to final customer via PPA[3]
- Financing is organized by the IPP

D) Customer wants PPA/Leasing – NEW IPP



- Equipment suppliers may own certain shares of the SPV[1]
- Together with (financing) partners they bundle several SPVs under a new legal structure (new IPP[2] company)
- IPP sells power to final customer via PPA[3]

1. Special purpose vehicle 2. Independent power producer 3. Power purchase agreement
Source: SMA analysis

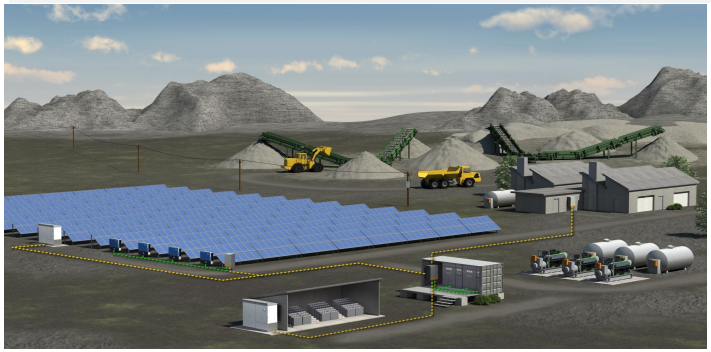
AGENDA

1. PV-Hybrid market opportunities
2. Financial attractiveness
3. **Technical solutions and references**
4. Summary and conclusion

DEPENDING ON APPLICATION, SYSTEM SIZE AND SYSTEM TOPOLOGY, WE FIND TWO MAIN CASES

Genset builds up the grid (PV as "slave")

- Several 100kW – multi MW
- Reducing OPEX (fuel saving)
- PPA structures

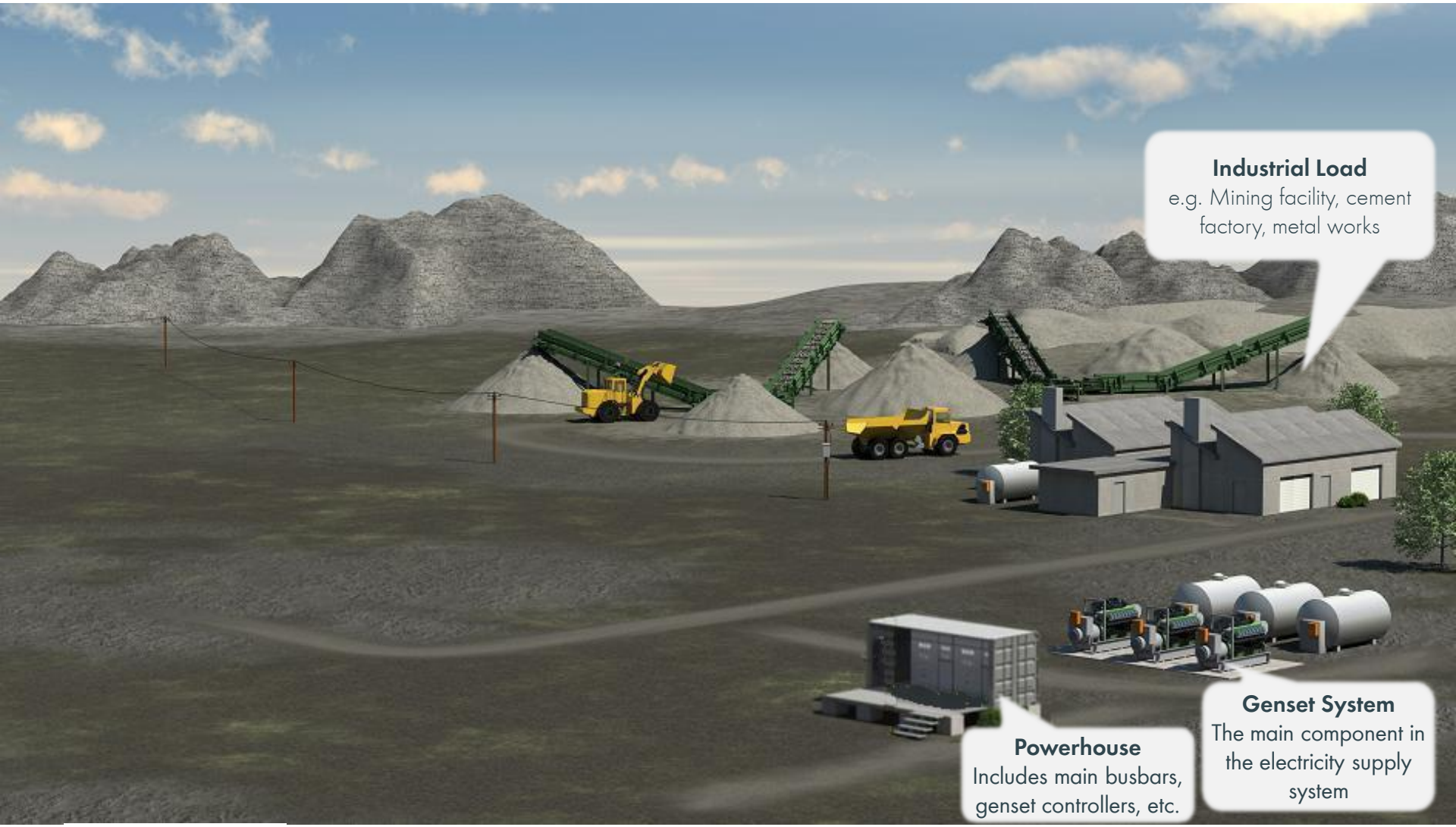


Battery inverter builds up the grid (PV + storage as „master", Genset supporting unit)

- Up to several 100 kW
- Rural electrif./reduction of power outages
- Governmental tenders + owned asssets

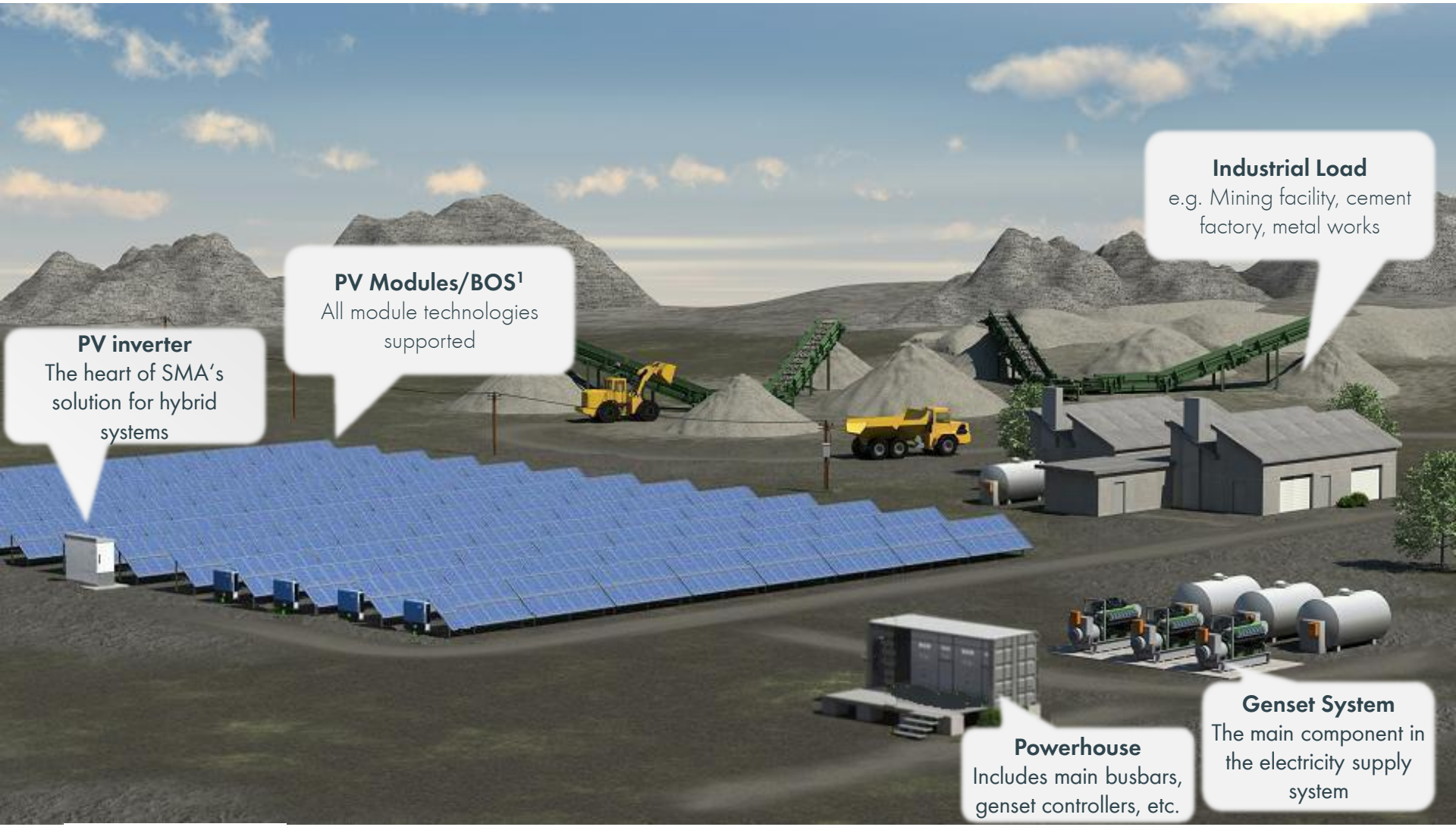
Source: SMA

INDUSTRIAL LOADS IN REMOTE AREAS: TYPICALLY SUPPLIED BY CONVENTIONAL GENSET SYSTEMS



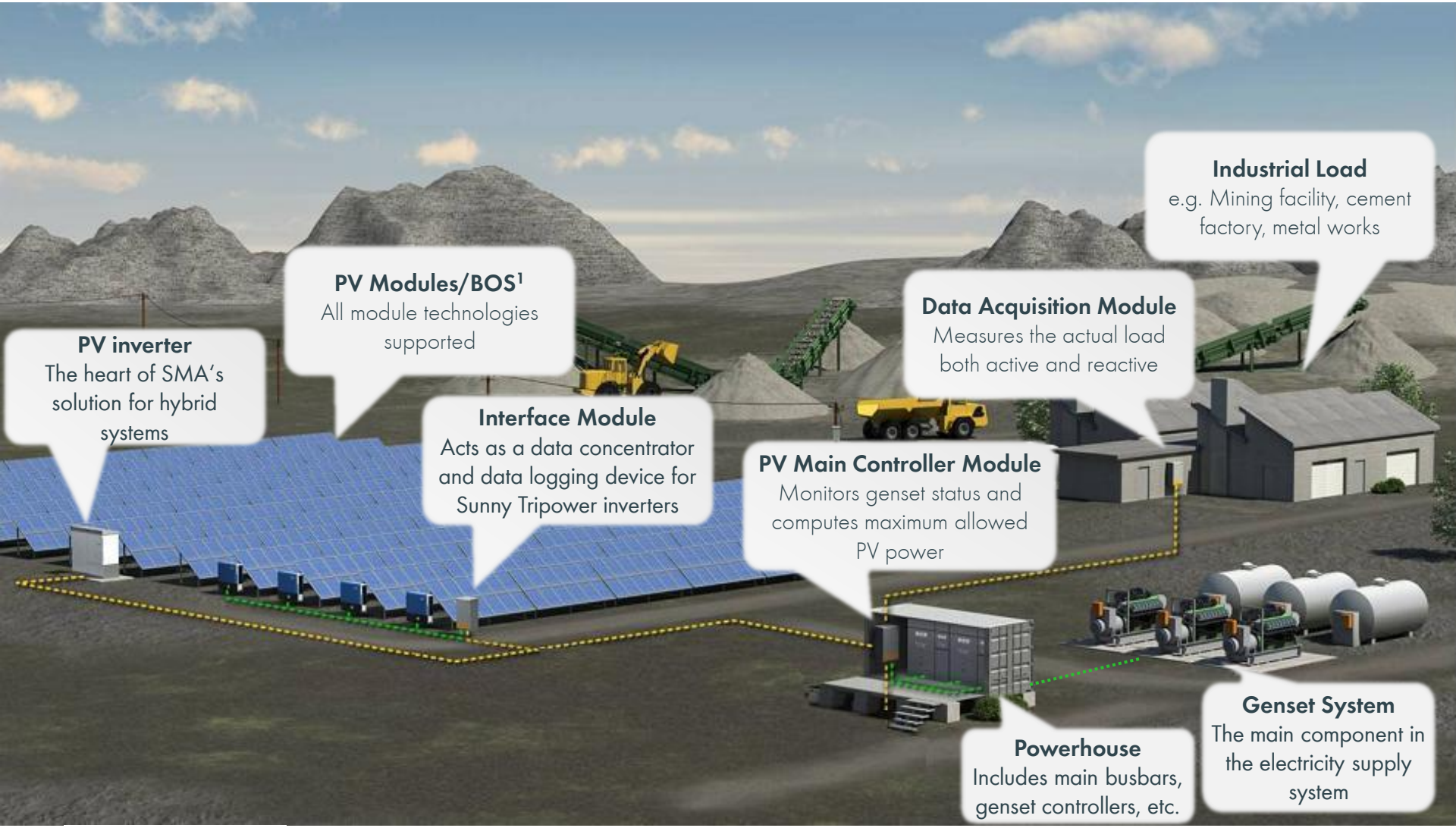
Source: SMA

ADDING PHOTOVOLTAICS IS THE FIRST STEP TOWARDS A FUTURE-PROOF SYSTEM...



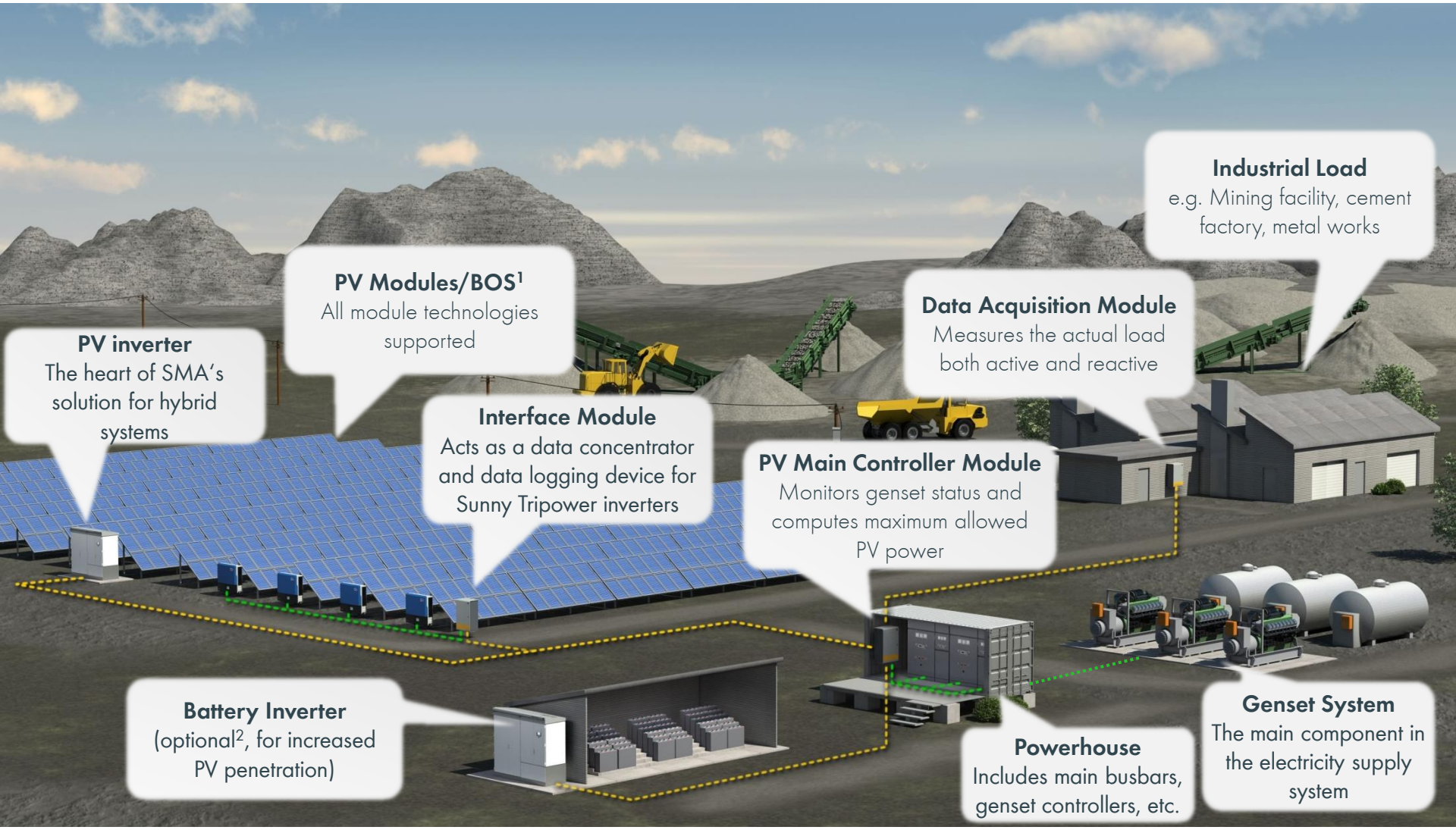
1. Balance of System (e.g. cabling, module racks, etc)

SMART COMMUNICATION BETWEEN GENSET AND PV: MANDATORY TO LEVERAGE THE FULL HYBRID POTENTIAL



1. Balance of System (e.g. cabling, module racks, etc)

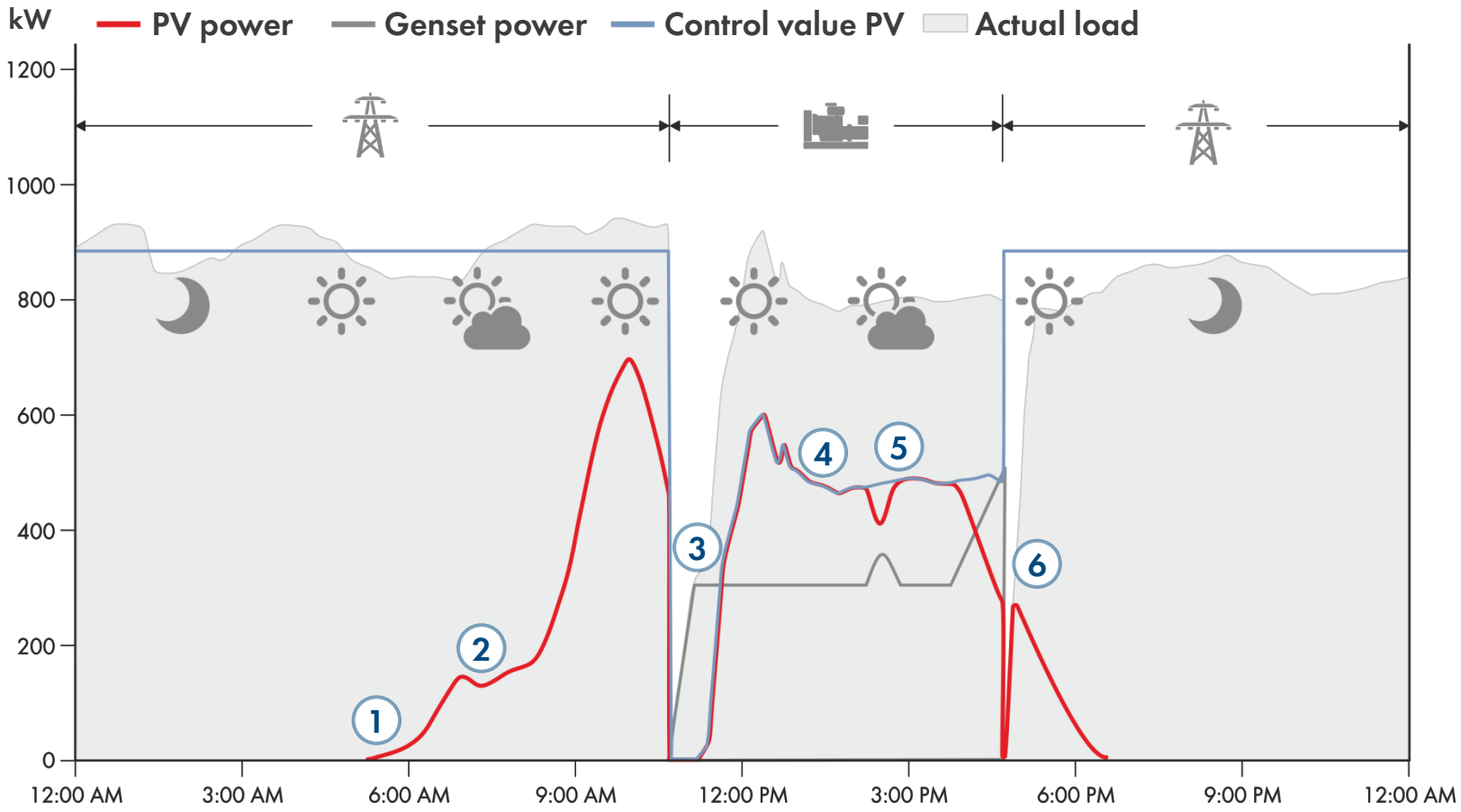
INTEGRATION OF STORAGE SMOOTHENS THE ELECTRICITY SUPPLEY AND INCREASES PV PENETRATION



1. Balance of System (e.g. cabling, module racks, etc)

2. Available by end of 2013

REAL-LIFE DATA: SMOOTH INTERACTION BETWEEN PV, GRID AND GENSET



1 Sunrise

2 Drop of PV power (clouds)

3 Grid failure, start of genset

4 PV covers load changes

5 Genset compensate cloud effect

6 Grid back again, PV synchronizes

Source: SMA project example

MINING: FIRST MW-SIZED PV-DIESEL HYBRID WORLDWIDE AT THABAZIMBI CHROME MINE

- Mining site in South Africa
- 2x800 kVA Perkins Gensets + 500 kVA grid connection
- Upgraded with 1 MWp PV
  - Modules: 4170 high-efficiency 240W poly-Si
  - Inverter: 63 STP[1] 17000 + FSC[2]
- PV power production: ca. 1.8 GWh p.a.
- Annual savings: approx. 450,000 liter Diesel fuel

1: Sunny Tripower Inverters from SMA. 2: Fuel Save Controller from SMA
Source: SMA Project Reference

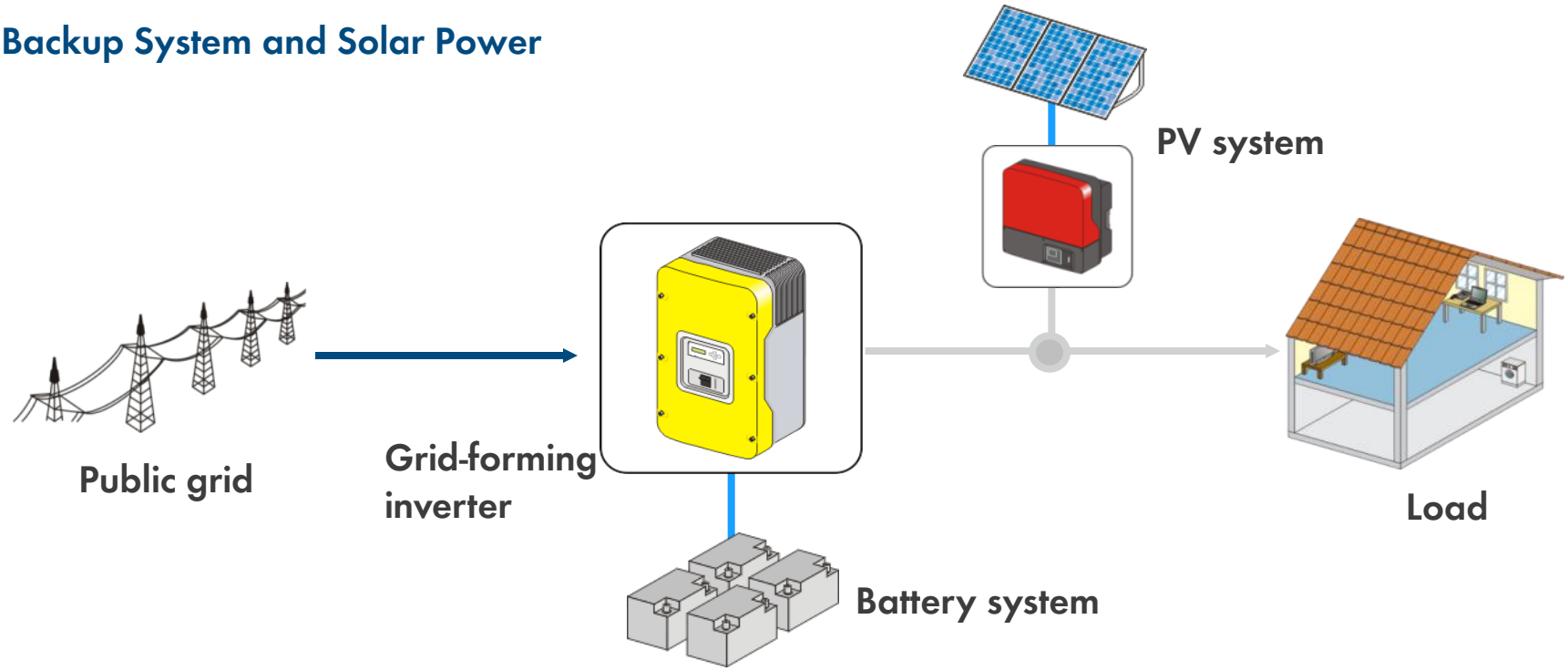
ISLAND: THE REFERENCE PROJECT IN TONGA ISLAND HAS A DISPATCHABLE BACKUP ENERGY CONCEPT

- 500 kWp PV plant with 21 x 20 000 TL SMA TriPower Inverters
- SMA Fuel Save Controller + 15 x SMA Sunny Backup 5000
- Includes 120 x 1,000 Ah gel lead acid batteries
- Saves 225,000 L of diesel p.a. and 440 tons of CO_2 emissions

Source: SMA project example

OFF-GRID AND BACKUP SYSTEMS WITH GRID-BUILDING INVERTERS

Backup System and Solar Power

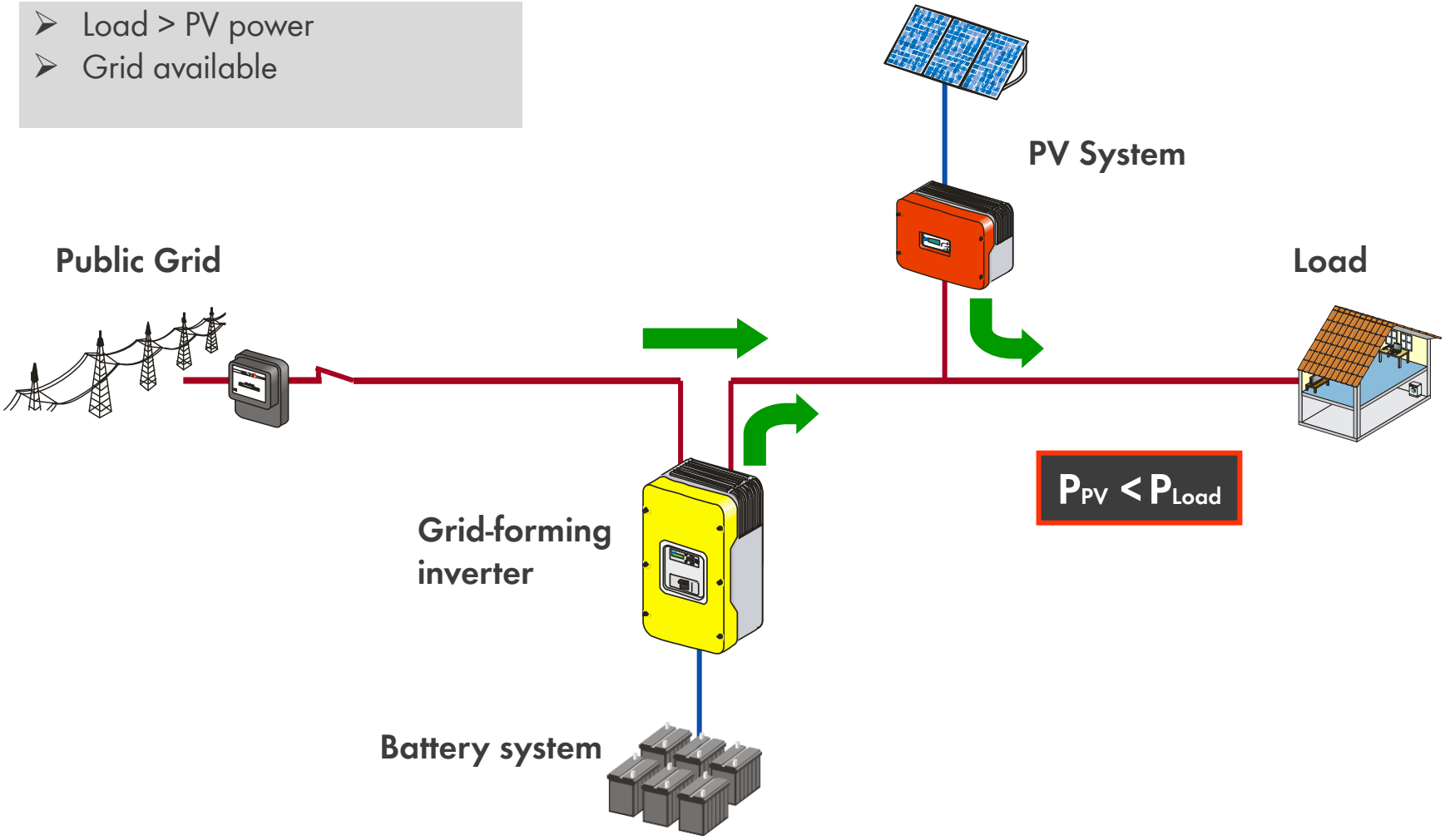


- Battery inverter forms and controls the stand-alone grid (battery, generator and load management)
- PV array and PV inverter supply the stand-alone grid (AC-coupled) with electricity
- Battery stores energy
- When the battery is empty, the public grid supplies the loads and charges the battery

Source: SMA

APPLICATION EXAMPLES – „PEAK SHAVING“

- Load > PV power
- Grid available

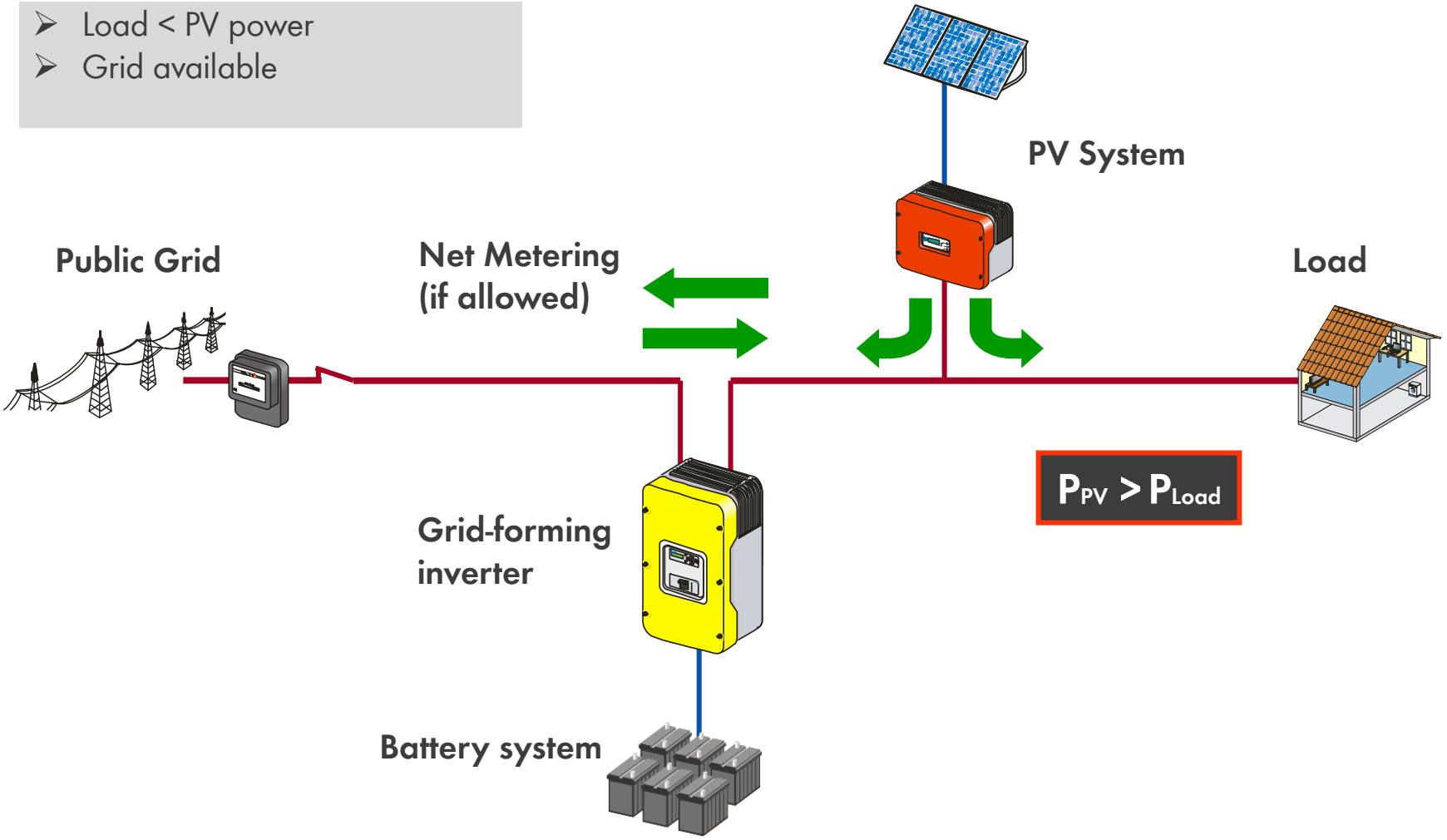


Many electricity tariffs charge extra cost for peak supply!

Source: SMA

APPLICATION EXAMPLES – „NET METERING“

- Load < PV power
- Grid available

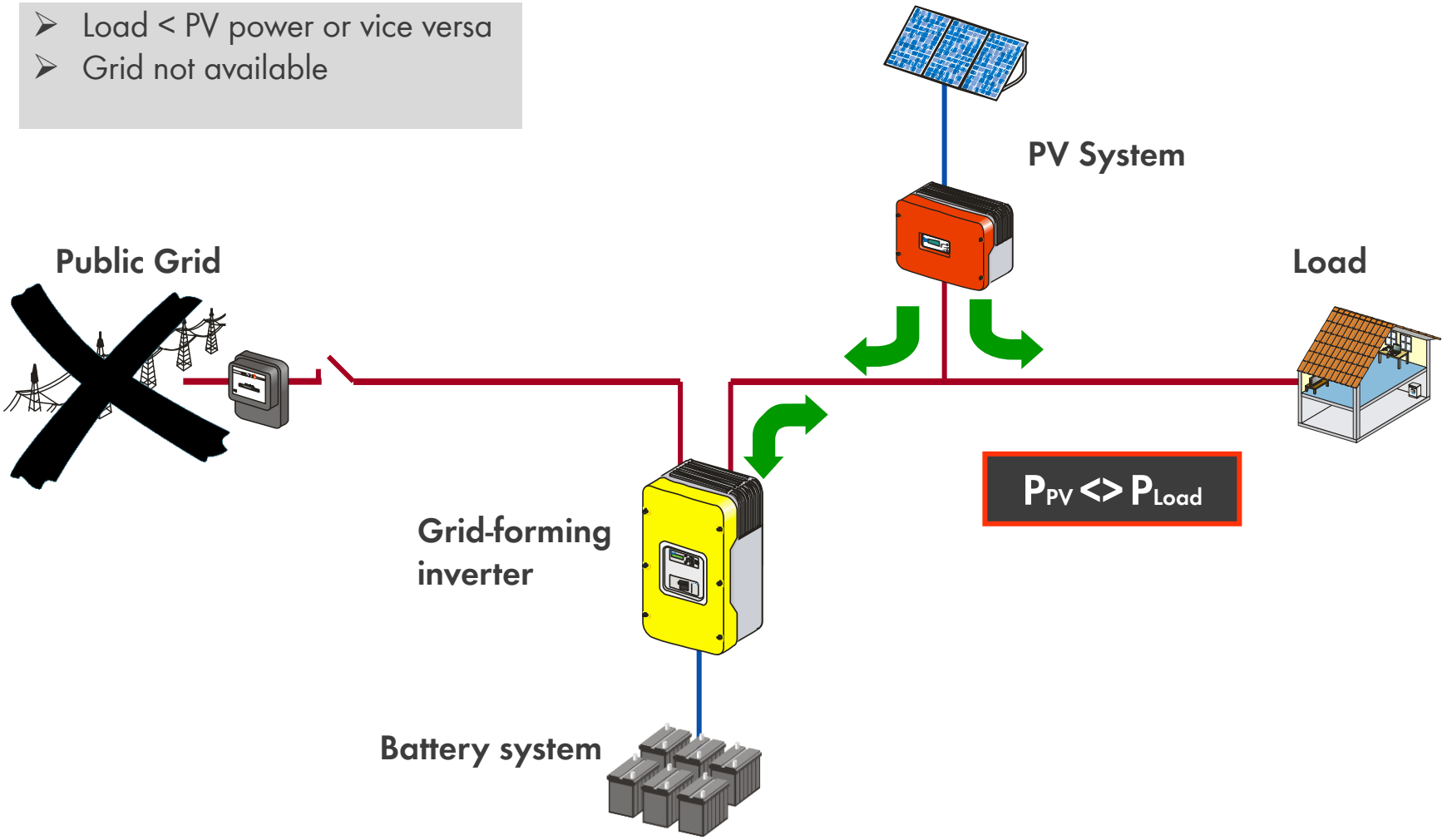


Net metering very attractive under many electricity tariff schemes!

Source: SMA

APPLICATION EXAMPLES – „BACKUP CASE“

- Load < PV power or vice versa
- Grid not available



Avoidance of power outages help bringing down opportunity cost significantly!

Source: SMA

TOKELAU PROOVES THAT A 100% PV + STORAGE IS VIABLE POWER SUPPLY FOR ISLANDS

- Tokelau is first country globally with 100% solar PV supply!
- 1MW PV (4032 PV modules, 205 SMA Sunny Boy Inverters)
- 8 MWh storage system (1,344 batteries, 93 SMA Sunny Islands + 121 Sunny Island Chargers)
- Saves ca. 200 liter Diesel fuel every day, zero CO_2 emmisions!

Source: SMA project example

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1. PV-Hybrid market opportunities
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SUMMARY AND CONCLUSION

- PV-Hybrid = significant fuel saving potential (proven by real-life references)
- Smart communication between Genset and PV secures system stability
- Payback times of 4-5 years feasible in sunny regions
- Project financing still a challenge in many regions → financing via platforms/aggregators can be a solution
- Power outages can be reduced by integrating storage
- Mid-scale solutions with grid-building battery inverters already exist

Outlook

- Integration of storage will further increase the PV penetration rate also for large-scale systems in the multi-MW range

Source: SMA

THANK YOU FOR YOUR ATTENTION!

PLEASE VISIT US AT BOOTH B2.210

FUEL SAVE SOLUTION AND OFF-GRID SOLUTIONS ON YOUTUBE:

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